Strong electron correlation effects in non-volatile electronic memory devices

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We have investigated hystereses of current-voltage characteristics associated with a negative differential resistance (NDR) both theoretically and experimentally. The hystereses have ever been reported a number of times in literature for some heterostructures of oxides, chalcogenites, and organic materials. The phenomena are expected as a possible candidate for the future non-volatile memory.

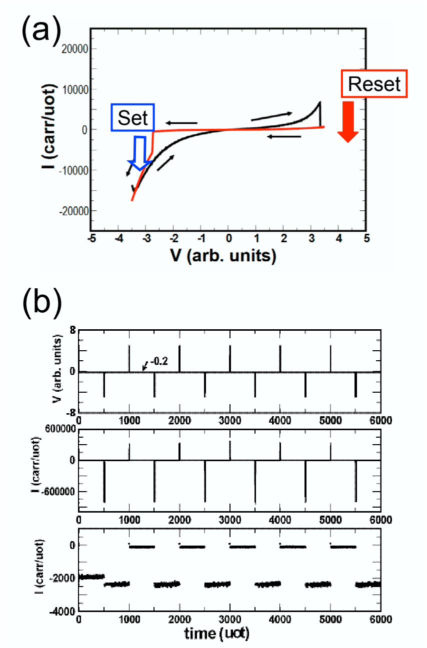

FIG. 1: **(a)** Hysteresis curve obtained using our model [2]. **(b)** Model simulation results of pulse-induced resistance switch. 1 uot = 1 unit of time = 1 Monte-Carlo step, in which the occupation number of all the domains are updated. Top panel shows the voltage protocol. The middle panel shows the current at the electrode. The bottom panel also shows the current in a different vertical scale that reveals more detailed behavior between the pulses.

In our theoretical investigation, we used a simple model [1] incorporating a multi-domain structure, which might be due to a phase separation or due to an inhomogeneous charge distribution realized by a so-called "electroforming" process. The model has shown that two mechanisms can reproduce the hystereses as well as NDR qualitatively similar to those experimentally observed.

One of the mechanisms is a interface-charge dependent tunneling which may be ascribed to a Schottky barrier. However, this mechanism alone is linked with poor non-volatile characteristics, possibly because it lacks a stabilization effect that could lengthen the lifetimes of the charge-accumulated (or -depleted) metastable states.

A physical mechanism that would enable such stabilisation is likely to be due to a *coherent* effect, in which many particles act in a correlated manner. The second mechanism that we have found is based on a Mott metal–insulator transition taking place in the domains near the metal/insulator interface [2]. Our hysteresis curve as well as the pulse-induced switching are shown in Fig. 1.

We have been also investigating the phenomenon experimentally by fabricating a metal/insulator/metal sandwich structure with several interesting correlated electron systems for the insulating matrix. We try to show the results of the experiment and compare those observed to the results of our model calculations. Details are given in the presentation.

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[1] M. J. Rozenberg, I. H. Inoue and M. J. Sánchez, *Phys. Rev. Lett.* **92**, 178302 (2004)
[2] M. J. Rozenberg, I. H. Inoue and M. J. Sánchez, *preprint* (http://arXiv.org/abs/cond-mat/0406646)